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Article

Maximizing Science Outreach on Facebook: An Analysis of Scientists' Communication Strategies in Taiwan

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Abstract
The internet, and especially social media platforms, offer scientists new opportunities to connect with a broader public. While many studies have focused on science communication on Twitter, surprisingly few have analyzed how scientists use Facebook, even though it is an essential platform for the general public in many countries. A possible explanation for this lack of research is that scientists keep their Facebook profiles separate from their work life and are more active on Twitter in their professional roles. Our study challenges this assumption by focusing on Taiwan as a peculiar case. Due to the local culture, Twitter is less popular there, and scientists are more active on Facebook, even in their professional roles. In our study, we analyzed 35 public pages of scientists on Facebook and assessed the factors explaining the reach of their communication using content analysis in combination with a multilevel model that allowed us to test predictors on the page level, such as the number of fans, in combination with predictors on the post level, such as the complexity of the language used. Our study shows that Facebook can play an influential role in science outreach. To effectively communicate with the audience on Facebook, it is best to use strategies that appeal to new and existing followers. Posts that address current issues and include opinions are likely to be shared widely, while humor or personal self-disclosure is likely to engage the existing audience. Our study contributes to the current debate about alternatives to Twitter in science communication.

Keywords
Facebook; science communication; self-disclosure; social media; Taiwan; Twitter

Issue
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1. Introduction

Nowadays, scientists are highly active on social media, and many studies have analyzed their social media usage. Early studies, especially of scientometrics, focused on communication on Twitter (Priem & Costello, 2010) or scholarly blogging (Puschmann & Mahrt, 2012). Since the early days of science communication on social media, new platforms have come to scholarly attention. For example, studies have analyzed science communication on YouTube (Debove et al., 2021; Yang et al., 2022), Instagram (Jarreau, Cancellare, et al., 2019), Reddit (Hubner & Bond, 2022), and even TikTok (Zeng et al., 2021). Moreover, while scientists have adapted well to the changing social media landscape, there has been a lack of engagement on Facebook, even though it is still among the most widely used social media platforms in many countries (Newman et al., 2022) and one of the primary sources from which regular citizens encounter scientific information and issues (Hargittai et al., 2018; Mueller-Herbst et al., 2020).

Facebook differs from other platforms commonly used for science communication, such as Twitter, in terms of its user base and features. Scientists often use Twitter to communicate with politicians, journalists, and other scientists (Jünger & Fähnrich, 2020; Walter et al., 2019); however, not many use Facebook for science outreach (McClain, 2017). Scientists may use Facebook personally, but not for professional science communication. In our study, we specifically focus on Taiwan because Facebook is one of the most popular social media platforms there and Twitter is not widely used, even among scientists. Furthermore, most Taiwanese people highlight the internet as their primary source of science-related information, and besides the messenger service Line, Facebook is the most popular social media platform in Taiwan (Shih, 2021). Since prior research on Taiwan has mainly focused on blogging about STEM disciplines (Lo, 2021) or a single Facebook page (Shan, 2017), we focus our study on different forms of Facebook pages with diverse disciplinary backgrounds. We are interested in what communication strategies are most successful on Facebook and lead to higher levels of user engagement. Since only a few specific studies of science communication on Facebook are available, we look at other fields, such as political communication, of which several studies exist that specifically analyzed Facebook communication. We also derive different factors that could influence communication outcomes from the broader science communication literature.

2. Science Communication on Social Media

The internet and social media platforms offer scientists new opportunities to connect with the broader public (Metag, 2021). However, while many studies have focused on science communication on Twitter (e.g., Jünger & Fähnrich, 2020; Rauchfleisch, 2015; Walter et al., 2019), surprisingly few have analyzed how scientists and science communicators use Facebook (Pavelle & Wilkinson, 2020), even though it is an essential platform for the general public (Mueller-Herbst et al., 2020). Therefore, we begin by briefly discussing the role that Facebook plays for scientists and how this lack of academic engagement on Facebook can be explained before we discuss which factors influence the success of Facebook communication.

2.1. Scientists' Social Media Usage

Nowadays, scientists are highly active on social media, and many studies have analyzed their social media usage. From a methodological point of view, there exist different strands of research on scientists' social media usage and its impact. While there have been several studies with experimental approaches that tested the effect of communication on citizens or directly surveyed citizens and how they engaged with science (e.g., Schäfer et al., 2018; Shih, 2016), we focus here mainly on survey research and analyze the content of scientists' communication on social media.

First, a plethora of studies have already generally analyzed how scientists interact with non-scientists in different countries, including Germany (Peters, 2013), Taiwan (Lo & Peters, 2015), and the US (Dudo & Besley, 2016), and usually focused on specific fields, such as climate change research (Post, 2016). However, few studies have focused explicitly on the role of social media. Early survey research from 2007 showed, for example, that even back then, many bioinformaticians were using social media (Anderson, 2008). However, it also identified that scientists' social media platforms were not primarily mainstream ones, such as Twitter or Facebook, but often specific niche platforms created for scientists (Anderson, 2008; Van Eperen & Marincola, 2011). Still, more recent survey research has shown that most scientists are using mainstream social media platforms but are still skeptical about Facebook, as they do not believe that the platform "provides an effective form of science communication" (Collins et al., 2016, p. 5). McClain's (2017) study also confirmed these findings, concluding that "many scientists have turned to Twitter instead of Facebook for science outreach.''

Besides this survey research, there also exists a strand of research that focuses explicitly on the social media behavior of scientists. Instead of using a survey approach, studies in this strand have usually analyzed digital trace data; for example, Jünger and Fähnrich's (2020) study focused on communication scientists on Twitter. Besides these studies focusing on specific disciplines that have analyzed internal communication between scientists, some studies have strongly emphasized external communication. For example, Walter et al. (2019) identified scientists through the issue of climate change and then checked how these researchers communicated with politicians and journalists on Twitter. In addition, some studies have tried to map scientists on Twitter, covering various disciplines (Ke et al., 2017). And while there are several studies that have specifically focused on other social media platforms besides Twitter (e.g., Debove et al., 2021; Hubner & Bond, 2022; Jarreau, Cancellare, et al., 2019; Jarreau, Dahmen, et al., 2019; Yang et al., 2022; Zeng et al., 2021), Facebook seems to remain understudied.

This lack of research is surprising since Facebook's potential for science communication was recognized early on (Nentwich & König, 2014). Although universities, as organizations, have recognized the potential of Facebook as a marketing tool (Assimakopoulos et al., 2017), and they use the platform more often than Twitter (Entradas et al., 2020), individual scientists still seem to be skeptical about the platform, as we have shown above. Most survey research has shown that individual scientists use the platform, but not primarily for science communication. However, studies highlighting these findings usually also mention the untapped potential of Facebook. McClain (2017), for example, suggested that a scientist who already has strong connections with family and friends on Facebook should become a so-called "nerd of trust" and start communicating more about science. The preference for Twitter and specific niche platforms for science communication indicates that a primary goal is peer-to-peer communication with other scientists. External incentive structures can explain the preference for platforms such as Twitter instead of Facebook. That research funders assess this form of public engagement serves as a primary external driver to use these platforms and communicate more strategically (Kessler et al., 2022). Tracking scholarly communication on Twitter is easy through so-called altmetrics that show how often a publication has been shared (Sud & Thelwall, 2014). On Facebook, on the other hand, these kinds of metrics are not publicly available, and only URLs to articles shared on public pages are tracked as altmetrics. Thus, purely for strategic communication that has as the primary goal of career advancement, Facebook is not an attractive platform.

So why should scientists use Facebook? Many still follow a public engagement model that emphasizes dialogic communication with the general public as well as the public understanding of science model, which primarily focuses on educating the public by taking a top-down approach to science (Kessler et al., 2022). Facebook is an ideal platform for science communication because it has a large public audience. According to Hargittai et al. (2018), young adults in the US are more likely to engage with science and research content on Facebook than on Twitter. Furthermore, citizens' Facebook usage can influence their awareness of scientific issues (Mueller-Herbst et al., 2020).

2.2. Successful Communication on Facebook

In our study, we are primarily interested in what factors explain scientists' communication success on Facebook. Since there are almost no studies available, we derive potential factors from the broader science communication literature and from studies of political communication, where analyses of Facebook communication are more common than they are in science communication. We identified a number of potentially positive or negative factors in the literature that could influence the success of communication via Facebook: (self-)promotion, the complexity of the communication, the use of data and infographics, emotional communication, and the disclosure of personal information.

The most apparent factor can be derived from Twitter research and clearly belongs to the strategic science communication model. Scientists may use Facebook to promote their research, targeting other scientists (Jünger & Fähnrich, 2020). They may also have blogs or podcasts and promote this content through their Facebook pages (Yuan et al., 2022).

How to cope with the complexity of issues and language when communicating with the public is a major concern in science communication (Mueller-Herbst et al., 2020; Wong-Parodi & Strauss, 2014). Regarding the language used in posts, the level of complexity may harm a communication's success. Different studies have highlighted how using jargon and complex language can overwhelm the public (August et al., 2020). Furthermore, while there is agreement that using less complex language is preferable, there is also the threat that using simplified language can lead to misinterpretations (Rice & Giles, 2017; Wong-Parodi & Strauss, 2014). Prior studies considering the complexity of language on social media platforms have measured complexity manually (Dalyot et al., 2022) or automatically (Hubner & Bond, 2022).

Like language complexity in science communication, data and infographic usage is also a double-edged sword. On the one hand, using visualizations has many benefits, such as increasing information recall and evoking more favorable attitudes towards an issue (Lee & Lee, 2022), and its potential has been recognized for science communication (Rodríguez Estrada & Davis, 2015; Ynnerman et al., 2018). On the other hand, using complex data visualization can lead to misunderstandings (Wong-Parodi & Strauss, 2014), and there may be various reasons why users choose to engage or not with data visualizations (Kennedy et al., 2016).

The potentially ambivalent role of emotions in science communication has been critically discussed in prior research (Taddicken & Reif, 2020). For example, fear appeals can increase attention to scientific issues (Lidskog et al., 2020) and lead to the intended emotional responses (Ettinger et al., 2021). Furthermore, from general Twitter research, we know that emotional messages are shared more often (Stieglitz & Dang-Xuan, 2013), a finding that also holds in political communication on Facebook (Keller & Kleinen-von Königslöw, 2018).

Humor as a specific communication style might be especially effective on social media platforms. For example, research on political communication (Keller & Kleinen-von Königslöw, 2018) and marketing research (Ge & Gretzel, 2017) have highlighted the role of humor in communication on social media platforms. The role of humor in science communication has also been analyzed. For example, scientists have used humor on Twitter to talk about their research (Simis-Wilkinson et al., 2018). In addition, research has shown that using humor on Twitter can positively influence messages' engagement levels (Su et al., 2022) and lead to a more positive evaluation of the communicator (Yeo et al., 2021).

Lastly, research has shown that scientists on Twitter also talk about political issues (Jünger & Fähnrich, 2020). In addition, many scientists use Facebook in their non-professional roles (Collins et al., 2016; McClain, 2017). But even for persons with a professional background, personal self-disclosure can be a viable communication strategy. Research on political communication on Facebook has shown that the use of personal self-disclosure can lead to higher user engagement levels (Keller & Kleinen-von Königslöw, 2018). However, Zhang and Lu (2022) showed in their experiment in the US context that personal self-disclosure on Twitter decreases the audience's perception of scientists' competence while at the same time increasing their likability.

Overall, we are interested in the following general research question: To what extent do the three forms of user engagement—likes, shares, and comments—

contribute to the effectiveness of scientists' communication on Facebook?

2.3. Science Communication in Taiwan

Survey research in Taiwan has shown that Taiwanese scientists are less mediatized than their counterparts in Germany (Lo & Peters, 2015) and that public engagement mainly happens at face-to-face events (Lo, 2021). The state of science journalism has been described in the past as concerning (Huang, 2014). The coverage of scientific issues is often done sensationally and potentially leads to misunderstandings, instead of a better-educated public. The lack of good science journalism in the mainstream media is among the reasons why many scientists have become active as bloggers on the internet (Cheng, 2014), and platforms such as *Pansci* were developed. The platform offers its own podcast and has a social media presence on every major social media platform (Shih, 2016). Even though there are good-quality science media in Taiwan, some of them are on the verge of going out of business, such as the Mandarin version of *Scientific American* and *Newton Magazine*, whereas *Young Scientist Monthly* has ceased publication (Xu, 2018). In Taiwan, the quality of journalism is generally a problem (Rauchfleisch & Chi, 2020; Rauchfleisch et al., 2022) that is also indicated by the low level of trust in the news (27%; Newman et al., 2022). Besides the messenger app Line, Facebook is the leading social media platform for news consumption (Shih, 2021). In contrast, Twitter does not appear in the list of the top six social media platforms (Newman et al., 2022). While Twitter has an essential role in many Western countries, and also for most international scientists, Taiwan is a peculiar case of science communication with Twitter being given low importance.

3. Data and Methods

To answer our research question, we collected Facebook data from the Crowdtangle platform. In our analysis, we focused on pages of individual scientists and collaborative pages run by a collective of scientists. We limited our sample in this study by only focusing on academic actors (scientists with an academic affiliation) and did not analyze professional science communicators who were not actively conducting research.

For the sampling, we started with broad disciplinary fields (e.g., social sciences, natural sciences, humanities). Besides the most-well known accounts (e.g., 陳建仁 Chen Chien-Jen, a scientist and the former vice-president of Taiwan), we identified pages for our sample with different approaches. First, we searched for the names of prominent scientists that often appear in the media. Secondly, we searched for Facebook pages that mentioned disciplines as a keyword (e.g., sociology). Thirdly, we searched for pages that mentioned "professor" (教授) as a keyword. In the last step, we checked the page recommendations shown when we added the pages identified on Crowdtangle to a dashboard. During our search, we found many public accounts of scientists that were not public pages and thus could not be included in our analysis. Furthermore, we excluded institutional academic pages as well as inactive accounts that had not published at least one post within the previous year. We did not aim to have a complete sample of all academic researchers in Taiwan on Facebook with public pages, but we ensured that we included a few pages for each of our disciplinary categories.

Our sample covered a wide range of disciplines and pages with different levels of reach in terms their number of fans (min. = 443; max. = 257,088). Thus, we had a mix of prominent and smaller pages by researchers. After filtering the pages according to the above-described criteria, we ended up with a sample of 35 unique pages (see the Supplementary File for an overview). Our sample covered various disciplines (humanities = 4, law = 2, medical and health = 11, social sciences = 11, STEM = 7), and there was a mix of individual (n = 29) and collective (n = 6) pages.

We then downloaded all the posts published on these 35 pages between 1 January 2020 and 31 May 2022. Based on the 13,146 posts, we created a stratified sample by taking either all a page's posts if that page had published fewer than 50 posts or a random sample of 50 posts per page. This approach gave us a final sample of 1,429 posts, which were used for the manual content analysis. Due to the stratified approach, this sample gave us enough power to detect even minor effects and capture enough diversity within each page. After dropping posts without textual content or any information that could be coded, we had a final sample of 1,248 posts.

The codebook was developed by all the authors in collaboration. For the content analysis, three of the authors coded the Facebook posts. All three coders were native Chinese speakers, had a background in journalism, and had different academic backgrounds (humanities, natural sciences, and social sciences), covering the diversity of the pages included in our study.

We added the factors discussed in the literature review to our codebook (for more extended definitions, see the codebook in the Supplementary File). First, self-promotion is essential for scientists using social media (Yuan et al., 2022). With the variable Promotion, we captured all posts that were done to promote any lecture, talk, podcast, or journal paper. As the level of complexity can hinder successful science communication (August et al., 2020; Mueller-Herbst et al., 2020; Wong-Parodi & Strauss, 2014), we coded the level of complexity (Sung et al., 2013) on a 10-point scale (1 = *extremely simple*; 10 = *extremely complex*). Since there is no universally agreed definition of complexity, we used the rather general definition of "features making a communicative task more or less complex" (Pallotti, 2015, p. 117). Additionally, we coded if any form of science-related statistics was reported (including simple percentages), infographics or data visualizations were used, or if there was a direct reference to a scientific source (e.g., journal article). For the emotional variables, we used Scaremongering (at least one sentence had to include a strong expression) as well as Humorous. Scaremongering was coded when a post used language that strongly emphasized dangers (Ogbodo et al., 2020). We coded a post as Humorous if at least one sentence included a form of humor (including sarcasm) or a (visual) meme was used. For calls to action and audience engagement, we adopted two variables from Keller and Kleinen-von Königslöw (2018). We coded a Call to Action if there was a direct call to do something related to the page (page owner). Audience engagement is related to what Keller and Kleinen-von Königslöw (2018) called pseudo-discursive style. We coded Audience Engagement if the audience was directly addressed in the post, including questions directed at the audience (e.g., asking for their opinion) or asking the audience to like, share, or comment on a post. We also included Personal Self-Disclosure as a variable. Keller and Kleinen-von Königslöw (2018) called this variable privatization, which captures if a post contains details from a person's private life. More specifically, in the science communication context, Zhang and Lu (2022) defined personal self-disclosure as the "sharing of personal interests, hobbies, and other non-science-related information" (p. 3). Lastly, since prior research has shown that scientists often comment on political issues or research in general on social media (Jünger & Fähnrich, 2020), we included the variable Opinion. We coded this variable when an opinion about any political or science-related issue was mentioned.

After creating a codebook covering all potential predictors (for an overview, see Table 1 here and the codebook in the Supplementary File), we ran three rounds of test coding (n = 20; n = 50; n = 60). While the majority of variables received high intercoder reliability in the first round, we discussed bad-performing variables. Eventually, we dropped broad variables such as Personalization, since we conceptually captured it with Personal Self-Disclosure, a variable that stands for a specific form of personalization. Almost all variables reached a Krippendorff's alpha of 0.7 (n = 60). Only the Opinion (0.65) and Sentiment (0.62) scores, as rather complex variables, were lower. We additionally validated the complexity measurement with an automatic classifier based on the measures used by education scientists to assess the difficulty of textbooks in traditional Mandarin (Sung et al., 2013). Over the complete sample, the human-coded 10-point complexity scale with the automatic complexity classification reached an alpha of 0.67. This result indicates that our scale was conceptually very similar to that developed in the educational context to measure the readability of textbooks. We also considered an automatic topic classification of posts but dropped this approach because the identified topics represented the pages' disciplinary focus, which had already been captured by the discipline variable.

For our analysis, we relied on Bayesian regressions that we estimated with the *brms* package in *R*. Because our data were nested with posts nested in pages and in disciplines, we used varying intercepts for both pages and disciplines. Not considering the nested structure of our data would have yielded biased estimates. For example, since it was plausible that some disciplines would

Table 1. Overview of all variables measured in the content analysis.

Variable	*M* (*SD*)
Science-related	74.60%
Statistics	9.50%
Infographic/data visualization	7.20%
Science source	13%
Humorous	14%
Scaremongering	5.40%
Audience engagement	5.80%
Call to action	19.60%
Promotion	54.20%
Personal self-disclosure	10.90%
Opinion	21.20%
Sentiment (−3 = *negative*; 3 = *positive*)	0.31 (1.06)
Complexity (1 = *extremely simple*; 10 = *extremely complex*)	3.04 (1.77)
Likes	757.78 (2,905.86)
Shares	63.93 (464.01)
Comments	26.78 (128.60)

Note: Based on all relevant posts (N = 1,248).

receive more public attention on average, the varying intercept would account for these differences. The same holds true for pages. Some pages, even if we considered all the variables in our model, including the second-level variable number of followers, receive on average more attention. The varying intercepts captured this variation on the page level. We opted for Bayesian models because they are often more robust than frequentist multilevel models (Stegmueller, 2013). Furthermore, while frequentist p-values and confidence intervals are often misinterpreted (Morey et al., 2016), Bayesian credible intervals can be directly interpreted as the 95% probability that the true value is within the interval. For all three models, we used four chains, each with 4,000 iterations in total and 1,000 iterations for burn-in. The chains all converged, and the Rhat scores were all 1. Sentiment and Complexity were scaled before being used in the models.

4. Results

As the three outcome variables were count data, we used negative binary regression models to answer our research question (see Table 2). For all three models, we used the same set of predictors. The number of followers as well as the collective page as page type were both entered as level 2 variables into the model since they were measured on the page level.

The first model showed that including an infographic or a data visualization led to more likes (IRR = 1.46, 95% CI [1.21, 1.76]). Using scaremongering expressions (IRR = 1.3, 95% CI [1.07, 1.59]) or expressing a personal opinion (IRR = 1.14, 95% CI [1, 1.30]) also increased the chance of receiving likes. While using language to encourage audience engagement (IRR = 0.79, 95% CI [0.64, 0.97]) or promoting something (IRR = 0.82, 95% CI [0.73, 0.92]) made it less likely to receive likes, sharing some private information (IRR = 1.34, 95% CI [1.16, 1.57]) increased the chance of receiving likes. Interestingly, using more complex language led to more likes (IRR = 1.16, 95% CI [1.09, 1.23]). Lastly, having more page followers increased the chance of receiving likes (IRR = 3.23, 95% CI [2.23, 4.65]).

For shares, we observed similar results as for likes. Using an infographic (IRR = 2.26, 95% CI [1.68, 3.02]), scaremongering expressions (IRR = 1.74, 95% CI [1.31, 2.39]), or more complex language (IRR = 1.46, 95% CI [1.33, 1.61]) all made it more likely that a post was shared. Additionally, sharing personal opinions or science-related information increased the chance of it being shared. However, sharing private information (IRR = 0.73, 95% CI [0.52, 0.93]) or something negative (IRR = 0.92, 95% CI [0.84, 0.99]) decreased the chance of it being shared. At the page level, our analysis showed that the more followers a page had, the more

Table 2. Negative binomial regression models for the outcome variables of likes, shares, and comments.

	Likes		Shares		Comments	
	IRR	CI (95%)	IRR	CI (95%)	IRR	CI (95%)
Intercept	148.46*	69.38–345.74	6.65*	2.96–16.24	5.57*	2.31–13.19
Science-related	1.08	0.95–1.22	1.36*	1.12–1.67	0.90	0.71–1.14
Statistics	0.95	0.82–1.11	1.08	0.85–1.39	0.95	0.69–1.34
Infographic/data visualization	1.46*	1.21–1.76	2.26*	1.68–3.02	1.63*	1.12–2.38
Science source	0.91	0.79–1.06	0.90	0.72–1.20	0.71*	0.53–0.96
Complexity	1.16*	1.09–1.23	1.46*	1.33–1.61	1.11	0.99–1.25
Sentiment	1.04	1.00–1.10	0.92*	0.84–0.99	0.90*	0.82–1.00
Scaremongering	1.30*	1.07–1.59	1.74*	1.31–2.39	1.53*	1.06–2.23
Humorous	1.14	1.00–1.30	1.10	0.90–1.37	1.62*	1.26–2.10
Audience engagement	0.79*	0.64–0.97	0.88	0.61–1.27	1.64*	1.06–2.57
Promotion	0.82*	0.73–0.92	0.99	0.83–1.21	0.82	0.65–1.03
Call to action	1.04	0.91–1.20	1.04	0.82–1.30	0.85	0.64–1.14
Personal self-disclosure	1.34*	1.16–1.57	0.73*	0.52–0.93	1.76*	1.32–2.36
Opinion	1.14*	1.00–1.30	1.35*	1.10–1.67	1.06	0.83–1.36
Science collective page	0.88	0.35–2.13	2.00	0.73–6.00	0.85	0.24–2.90
Page followers	3.23*	2.23–4.65	2.57*	1.68–3.93	2.86*	1.75–4.65
n pages	35		35		35	
n disciplines	5		5		5	
n	1,248		1,248		1,248	
Bayes-R	0.67		0.54		0.35	

Note: Incidence rate ratios are shown with 95% CI; an asterisk (*) indicates that the 95% CI does not include 1.

likes its posts received on average (IRR = 2.57, 95% CI [1.68, 3.93]).

In our third model, we used the number of comments as the outcome variable. Again, using an infographic or data visualization (IRR = 1.63, 95% CI [1.12, 2.38]) increased the chance of receiving comments. Likewise, sharing private information (IRR = 1.76, 95% CI [1.32, 2.36]), adding humor (IRR = 1.62, 95% CI [1.26, 2.10]), or using scaremongering expressions (IRR = 1.53, 95% CI [1.06, 2.23]) made it more likely to receive comments. On the other hand, the more negative a post, the less likely it was that the post received comments (IRR = 0.90, 95% CI [0.82, 1]). Also, having a direct reference to an academic publication in the post led to fewer comments (IRR = 1.14, 95% CI [1.06, 1.24]). The number of page followers was also one of the strongest predictors for the number of comments a post would receive (IRR = 2.57, 95% CI [1.68, 3.93]).

5. Discussion

Over the years, the development of science communication in Taiwan has evolved from the early stage of "science popularization" to "public understanding of science" and then to the idea of public communication, namely "public engagement with science and technology," which emphasizes that science in society should abandon the one-way communication model and instead adopt a two-way dialogue (Chin et al., 2015; Huang, 2022). However, there are still challenges for science communication in Taiwan, such as low public participation, over-dependence on translated science news, and concern about misinformation when audiences pay attention to individuals instead of science media (Huang & Lo, 2022). Our analysis shows that many of the measured variables are substantial predictors of audience engagement levels. While we identified overall many substantial predictors that more or less indicated the same relationship for all three outcome variables, we also noted some predictors that were not the same for each of them. For example, sharing private information in a post led to more likes and comments while also making it less likely that a post would be shared. A closer reading of social media posts with personal self-disclosure confirms these findings from the quantitative content analysis. Indeed, posts with personal self-disclosure usually include pictures from traveling (e.g., a visit to Disneyland) or of food, family members, and pets. Thus, scientists still sometimes deviate from their professional role and show themselves as regular users with private lives and hobbies (Collins et al., 2016; McClain, 2017). Somehow related to personal self-disclosure is sharing opinions about political issues that are sometimes not even connected to the scientist's research background. However, unlike personal self-disclosure, posts with personal opinions led to more shares. These results show that personal opinions about current affairs can strategically increase a page's reach (more shares) and potentially recruit new followers, whereas personal self-disclosure helps to engage the existing audience since it leads mainly to more likes and comments.

There is a need for further investigation of the potential negative and positive impacts of personal self-disclosure on scientists' perceived competence. Zhang and Lu (2022) found that personal self-disclosure can lower perceived competence. However, this may not necessarily be the case when scientists, such as those in our study, are already well-known or have become more familiar to their audiences through their Facebook pages. Future research should take this into account and examine the role of gender, which has been shown to affect user reactions on social media platforms such as Facebook (Dalyot et al., 2022) and Instagram (Jarreau, Cancellare, et al., 2019). It is still an open question whether gender influences the impact of self-disclosure on perceived competence.

Emotional content also can lead to higher user engagement levels, with scaremongering a substantial predictor for all three outcome variables and Humor only for comments. This finding confirms the findings from prior research on Twitter (Su et al., 2022). It also shows that emotionalized content can indeed increase communication reach (Taddicken & Reif, 2020).

The most counterintuitive result was the substantial positive effect of language complexity. While the complexity of language has traditionally been described as a significant challenge in science communication that potentially hinders successful communication (Rice & Giles, 2017; Wong-Parodi & Strauss, 2014), our study shows that the higher the complexity in a post, the higher the user engagement levels overall. One possible explanation for this could be self-identity as the user's motivation. Prior research in Taiwan has shown that self-identity correlates with the sharing of science-related information (Shih, 2016). Another potential explanation could be cultural factors, as Taiwan is a rather peculiar case that challenges many findings from the Western context (e.g., Shein et al., 2014). Last but not least, previous research has shown that the use of visualization for interpretation, explanation, and persuasion by science communicators has become an important technique and skill in Taiwan (Lee & Huang, 2018). In our study, we also observed an overall positive effect for infographics and visualizations, which can be explained by the increasing use of data visualizations during the Covid-19 crisis and also is in line with positive results from experimental studies (Lee & Lee, 2022).

Chin et al. (2015) indicated that the communication skills of Taiwanese scientists are an important key to the realization of the "citizen scientist" and "open science." To reach these goals, the factors mentioned above could be helpful for Taiwanese scientists to better communicate with their readers and further expand their potential audience reach via Facebook.

6. Conclusion

Our findings are important in the context of the current debate on alternatives to Twitter. While some scientists have migrated to Mastodon, it is not yet a platform that is used by the general public. Therefore, if the goal is to reach a wider audience beyond just peers, Facebook may be a viable alternative to Twitter. Our study shows that science communication can be successful on Facebook and that different strategies can be combined to achieve different communication goals. For science communication practitioners and scientists on Facebook, this shows that the best communication strategy is probably to use a communication mix that tries to attract new followers by creating posts that are widely shared and include opinions on current issues and posts that use humor or personal self-disclosure as a communication style to engage the existing audience. We also show that the complexity of issues and language and the sharing of data visualizations can have positive effects. However, this is also one of the main limitations of our study. We cannot satisfactorily explain why people engage with content on Facebook. Furthermore, we also have no precise information about the audiences that follow these pages. However, at least from reading some of the comments that posts received, we know that many active followers are regular citizens, and the primary goal of scientists with public pages does not seem to rest on peer-to-peer communication with other scientists. Still, we did not include the content of the comments that the posts received in our analysis. Future research should focus specifically on the users following these pages and could also use experiments to test some of the findings in our study (cf. Zhang & Lu, 2022). Lastly, future studies could include other science communicators on Facebook without a direct academic connection and use comparative research designs that compare different platforms (e.g., Su et al., 2022) or countries.

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Conflict of Interests

The authors declare no conflict of interest.

Supplementary Material

Supplementary material for this article is available online in the format provided by the author (unedited).

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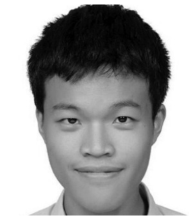

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